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"Efficiency - Equity - Clarity"

The Future Isn't What It Used To Be

Changing Trends And Their Implications For Transport Planning

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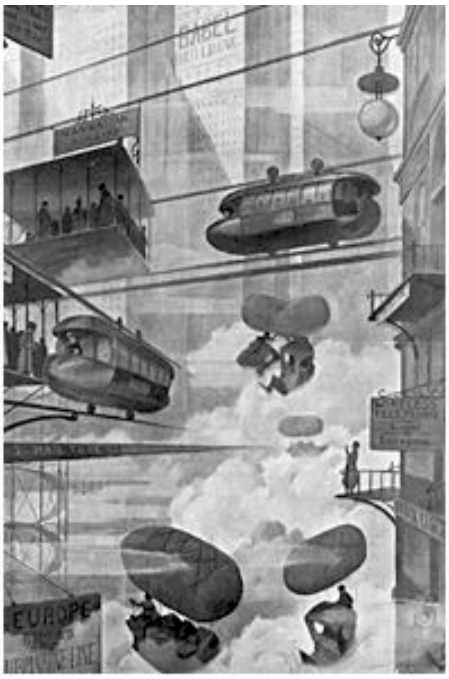


Future transportation imagined by Fred Strothman in 1900.

Abstract

This paper examines demographic, economic and market trends that affect travel demand, and their implications for transport planning. Motorized mobility grew tremendously during the Twentieth Century due to favorable demographic and economic conditions. But many factors that caused this growth, such as declining vehicle operating costs and increased vehicle travel speeds, are unlikely to continue. Per capita vehicle ownership and mileage have peaked in the U.S., while demand for alternatives such as walking, cycling, public transit and telework is increasing. This indicates that future transport demand will be increasingly diverse. Transport planning can reflect these shifts by increasing support for alternative modes. Although this paper investigates trends in the U.S. and other wealthy countries, the analysis has important implications for developing countries.

A condensed version of this paper was presented at the
85th Transportation Research Board Annual Meeting, January 2006.

Contents

Past Visions of Future Transportation

1939 Futurama

1949 ConvAIRCAR Flying Car

1958 Ford Firebird III, which included the "Autoglide" automated guidance system.

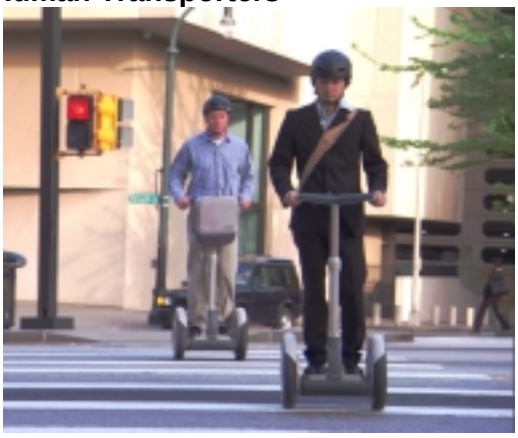
1950 Hiller Flying Platform

Introduction

According to predictions made a few decades ago, current travel should involve self-driving automobiles, jetpacks and flying cars, with space transport a common occurrence.[1] Travel should be increasingly convenient, comfortable, safe and cheap.

General Motor's 1939 Worlds Fair *Futurama* display predicted that by the 1960s, uncongested, 100-mile-per-hour superhighways would provide seamless travel between suburban homes and towering cities in luxurious, streamlined cars. In 1961, *Weekend Magazine* predicted that by 2000, "Rocket belts will increase a man's stride to 30 feet, and bus-type helicopters will travel along crowded air skyways. There will be moving plastic-covered pavements, individual hoppicopters, and 200 m.p.h. monorail trains operating in all large cities. The family car will be soundless, vibrationless and self-propelled thermostatically. The engine will be smaller than a typewriter. Cars will travel overland on an 18 inch air cushion."

Figure 1 **Segway Human Transporters**



Segway is an example of a new motorized transport mode.

Although several new modes developed during the Twentieth Century, including airplane, automobile,[2] and containerized freight, transport innovations have been more modest in recent decades, and none have displaced existing modes. Commercial air travel has not reduced the importance of walking, automobile or public transit for local mobility, and Segways have not significantly replaced walking or driving.

Transportation professionals help create the future, so it is important that we consider the overall context of long-term planning decisions. Good planning does not consist of simply extrapolating past trends, it requires that we understand the fundamental conditions which cause change. This paper examines various demographic and economic trends that affect travel demand and their implications for transport planning.[3]

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[1] For example, *2001 A Space Odyssey*, 1968, shows scheduled, commercial moon travel. Also see *Retro Future* (www.retrofuture.com); *Flying Contraptions* (www.flying-contraptions.com); Corn, 1984; Cosgrove and Orrick, 2004.

[2] In this paper, *automobile* refers to all personal motor vehicles, including cars, vans, light trucks, sport utility vehicles, and even motorcycles.

[3] *Travel demand* refers to the amount and type of travel people would consume at a given price and quality.

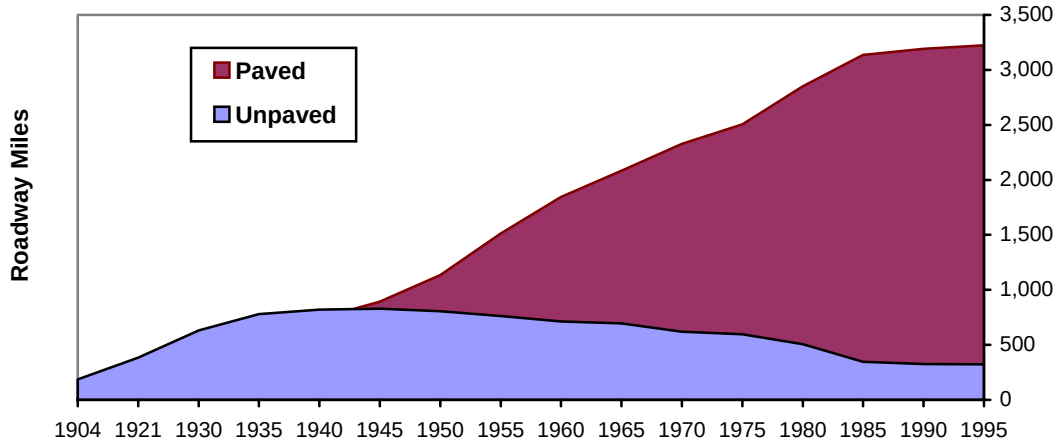
Twentieth Century Transport Trends

This section summarizes how transportation infrastructure, vehicle ownership and use developed during the Twentieth Century.[4]

Transportation Infrastructure

Several new transport modes developed during the Twentieth Century, including highways, airports and containerized freight systems. At the start of the century most roads were unpaved. Roadway mileage and quality increased tremendously during the first half of the century culminating in the Interstate Highway System. Since that system was virtually completed in the 1980s there has been little roadway expansion, as indicated in Figure 2. Similar patterns occurred in other developed countries.

Figure 2 **US. Roadway Mileage** (MVMA, 1995, p. 69)



Roadway mileage grew significantly between 1900 and 1980. Little growth has occurred since.

Railroad mileage increased during the first half of the Twentieth Century and declined during the second half, but the decline has stopped, and Class 1 track mileage increased slightly between 2000 and 2002. Many major rail lines and terminals are now being upgraded to accommodate more rail traffic and container volume.

Airport and port infrastructure expanded significantly during much of the Twentieth Century. Some growth continues, particularly those that serve as major transfer hubs, but much of the growth is being accommodated by incremental improvements and better management of existing facilities.

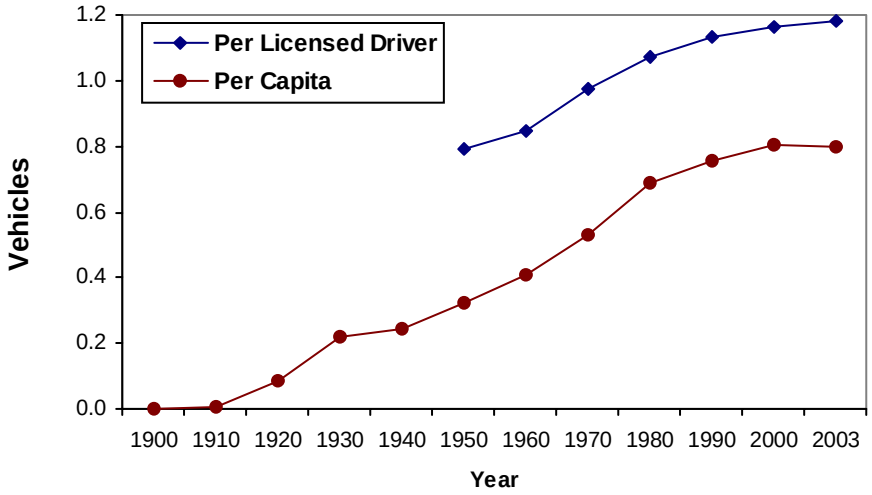
Transit service declined significantly during much of the Twentieth Century, due to a spiral of declining investment, service quality and ridership, but this has been reversed as many cities reinvest in transit infrastructure and implementing policies that increase service quality and encourage ridership. For example, between 1995 and 2002 bus route miles increased about 20% and rail transit track mileage by about 40%.

[4] Some data are limited and unreliable, particularly for the early years of the Twentieth Century. The best data sets we could find are presented here.

Vehicle Ownership

Per capita motor vehicle ownership grew during most of the Twentieth Century, but leveled off about the year 2000, and declined slightly since then, as illustrated in Figure 3.

Figure 3 **US. Vehicle Ownership Growth** (FHWA, Various Years)



Vehicle ownership grew during most of the Twentieth Century, reaching more than one vehicle per licensed driver by the year 2000. Per capita vehicle ownership rates peaked in 2000.

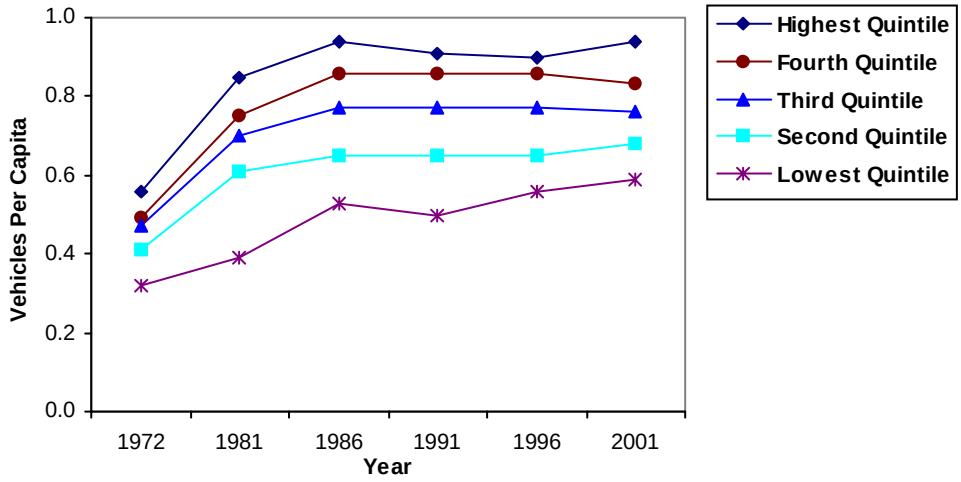
Figure 4 illustrates per capita automobile ownership trends by income class from 1973 to 2001. Ownership rates increased significantly during the 70s, and for lower-income households during the 80s, but flattened and declined in some classes during the 90s. The period of growth in per capita vehicle ownership rates coincided with Baby Boomer's peak driving years, and significant growth in the portion of women employed outside the home.[5]

Between 2000 and 2003 New York City recorded a 5% decline in total registered vehicles.[6] Taking only standard vehicles into account (excluding taxis, rental cars, and motorcycles) the average reduction is over 7%. Experts say this results from increased vehicle insurance, parking and fuel prices.

[5] For more detailed analysis of factors that contributed to increased vehicle travel demand from the 1960s through the 1990s see analysis of the National Personal Transportation Survey (NPTS) by Pisarski (1992) and Hu and Young (1999).

[6] Based on a report by *Crain's Detroit Newsletter* (www.crainsdetroit.com), February 2005.

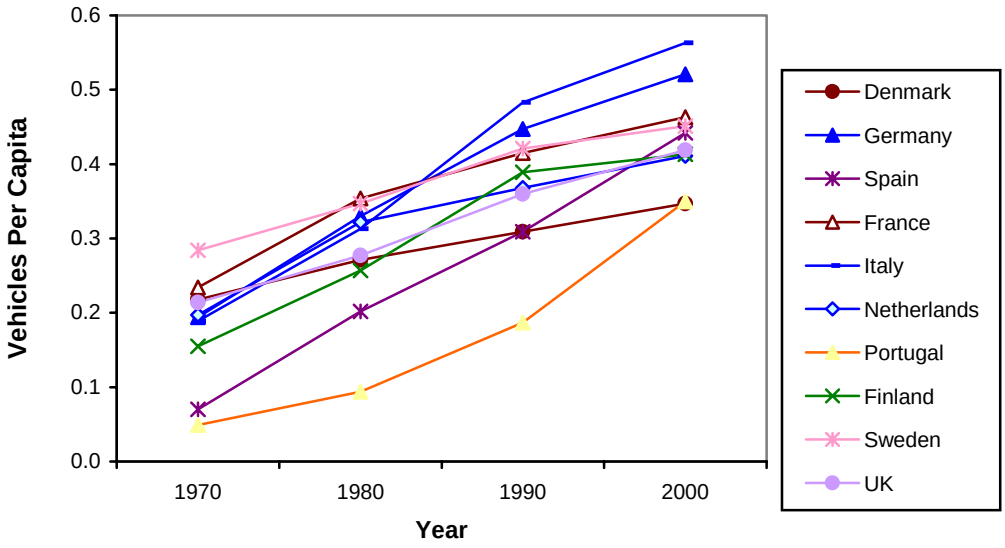
Figure 4 **Vehicles Per Capita By Income Class** (BLS, Various Years)



This graph shows motor vehicles per capita by income quintile. This increased significantly during the 1970s, but leveled off during the 1990s.

International data, illustrated in Figure 5, indicates that during the 1990s, per capita vehicle ownership growth rates started to decline in other wealthy countries such as Denmark, Germany, France, Italy, Finland, Sweden and the U.K., and appear likely to level off at a point lower than the 0.75 peak reached in the U.S.

Figure 5 **International Vehicle Ownership** (EC, 2002)

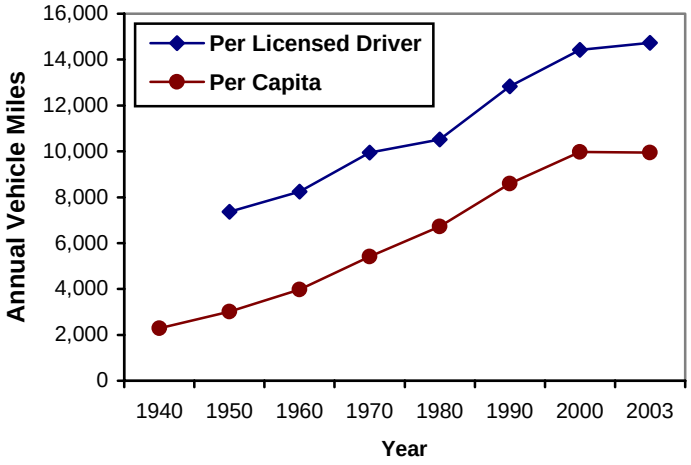


Vehicle ownership grew in European countries between 1970 and 2000, particularly in lower-income countries such as Portugal and Spain. Growth rates declined during the 1990s in wealthy countries such as Denmark, Germany, France, Italy, Finland, Sweden and the U.K.

Vehicle Mileage

During most of the Twentieth Century, motor vehicle mileage rates grew significantly, but these have also leveled off and even declined slightly since 2000.

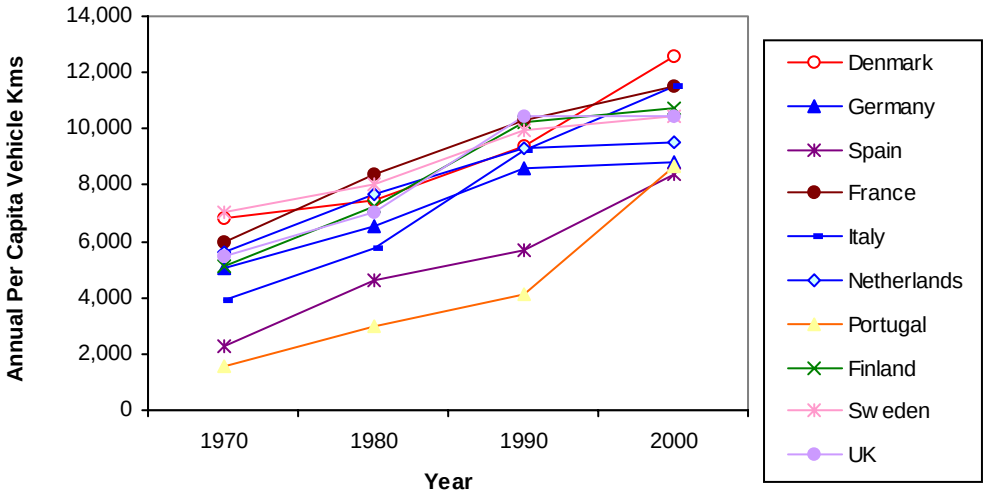
Figure 6 **U.S. Average Annual Vehicles Mileage** (FHWA, Various Years)



This figure shows average motor vehicle mileage per driver and per capita. These rates increased significantly though the 1990s, but peaked about 2000.

Similar patterns occurred in other developed countries. Figure 7 illustrates per capita vehicle travel rates in European countries between 1970 and 2000. Per capita mileage grew fastest in lower-income countries that started with low mileage rates, such as Portugal and Spain. Growth rates declined during the 1990s in most wealthy countries such as Germany, France, Finland, Sweden and the U.K., and appear to be leveling off at a far lower point than the 16,000 average annual kilometers per capita in the U.S.

Figure 7 **International Vehicle Travel Trends** (EC, 2002)



Per capita vehicle travel grew in European countries between 1970 and 2000, particularly in lower-income countries such as Portugal and Spain. Growth rates declined during the 1990s in wealthy countries such as Germany, France, Finland, Sweden and the U.K.

Per capita automobile travel in the United Kingdom peaked at 5,570 annual miles (9,280 kilometers) in 1998/2000, and declined slightly since, while walking, cycling, and motorcycle travel, which had previously been declining rapidly, declined only slightly, while local bus transit increased (Table 1). Average disposable income in the U.K. grew about 12% during this period.

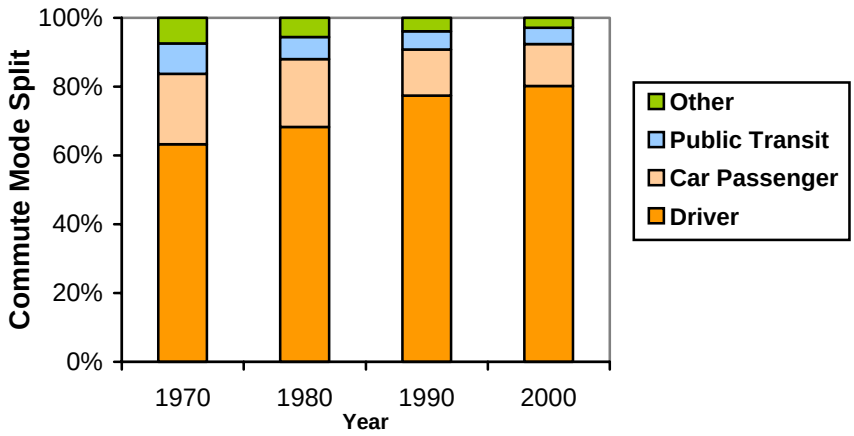
Table 1 **UK Annual Per Capita Mileage By Mode** (DfT, 2004, Chapter 2)

Year	Car	Walk	Bike/Motorcycle	Local Bus	Rail/Tube	Other
1985/86	4,024	244	95	297	336	322
1989/91	5,107	237	79	274	416	363
1992/94	5,235	199	70	259	348	328
1995/97	5,448	195	69	252	345	356
1998/00	5,570	192	69	245	428	336
2002/03	5,562	191	68	260	417	356

UK automobile mileage grew until 2000, after which it declined slightly.

At the start of the Twentieth Century walking, cycling, horse, and public transit were all important modes. During the century, automobile travel increased relative to other modes, becoming dominant. Figure 8 shows commute mode split trends from 1970 through 2000, indicating an increasing portion of commute trips are by automobile. Other countries also experienced increased automobile commuting during this period, although not to such as degree as in the U.S.

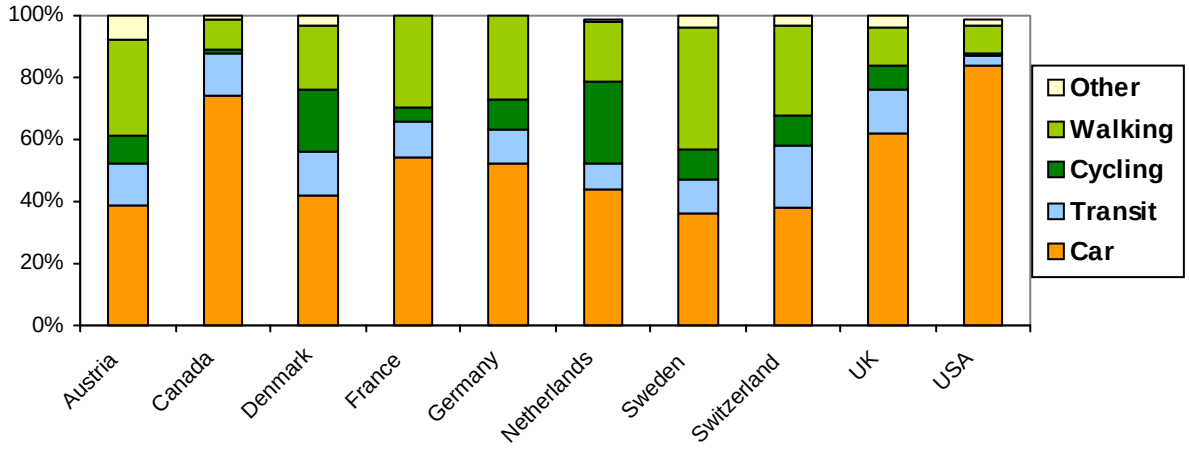
Figure 8 **U.S. Commute Mode Split Trends** (U.S. Census Data)



This figure, and other travel trend data, indicate that automobile travel dominates commute trips.

International comparisons indicate that mode splits vary significantly from one area to another. Many wealthy countries, such as Denmark, Sweden and Switzerland, have relatively low automobile mode split, as indicated in Figure 9. Factors such as land use development patterns, urban highway supply, the quality of transit service, walking and cycling conditions, and parking facility supply and price affect mode split.

Figure 9 **Urban Mode Split** (Pucher and Lefevre, 1996)



This figure shows large variations in urban mode split among developed countries, indicating that increased wealth does not necessarily lead to automobile dominance.

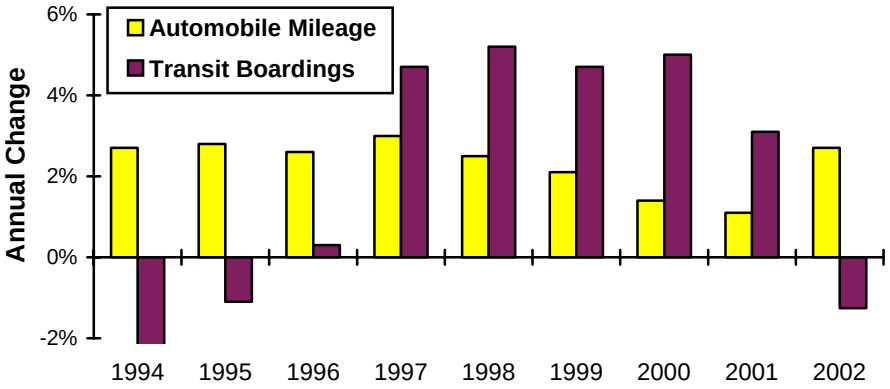
It is worth noting that these conventional travel statistics exaggerate the importance of automobiles relative to other modes, due to the way travel activity is measured ("Measuring Transportation," VTPI, 2005). Most travel surveys only count the primary mode used for peak-hour zone-to-zone trips. Short trips, non-commute trips, travel by children, and nonmotorized links of transit or automobile trips tend to be undercounted.

More comprehensive surveys indicate higher levels of alternative modes, particularly walking. If instead of asking, "What portion of trips only involve walking?" we ask, "What portion of trips involve some walking on public sidewalks or paths?" the number of nonmotorized trips more than doubles (Litman, 2003). Similarly, if instead of asking, "What portion of total trips are by public transit?" We ask, "What portion of peak-period trips on congested corridors are by transit?" or "What portion of residents use public transit at least occasionally?" the numbers are much higher. Even people who do not currently use transit value having it available, in case they need it in the future.

The units used to measure transport also affect the relative importance of different modes. Alternative modes may seem insignificant when evaluated by distance traveled but not by trips or travel time. For example, according to the 2003 *U.K. National Travel Survey* automobile travel accounts for about 25 times as much mileage as alternative modes, but only 2.5 times as many *trips*, and only 3 times as much *travel time* (Litman, 2003). Large increases in the share of travel by automobile during the last century reflect increased motorized mileage rather than large reductions in walking, cycling or transit travel.

U.S. transit ridership declined during most of the Twentieth Century, but starting in the late 1990s it began to grow again, increasing faster than automobile travel during most recent years (Figure 10). This period coincided with a growing economy and declining real fuel costs, factors that should favor driving over transit. This suggests that fundamental shifts are occurring that increase transit demand.

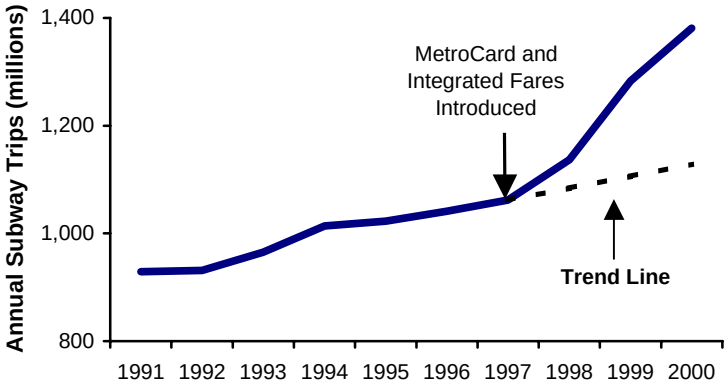
Figure 10 **Annual Growth in Automobile and Transit** (APTA & FHWA Data)



Between 1997 and 2001, transit use grew faster than automobile use. (The ridership decline in 2002 reflects, in part, the effects of the September 11, 2001 terrorist attacks).

Transit ridership has increased in many specific markets, particularly after introduction of service improvements, pricing reforms, and transit-oriented development (TRL, 2004). For example, in 1997 after the New York transit system introduced automated fare cards and a new fare structure that substantially reduced the cost of many trips, transit ridership increased about 30%, as illustrated in Figure 11.

Figure 11 **New York City Subway Ridership** (www.schallerconsult.com)



New York transit ridership grew substantially after the MetroCard was introduced in 1997. Bus ridership (not shown) grew even more during this period.

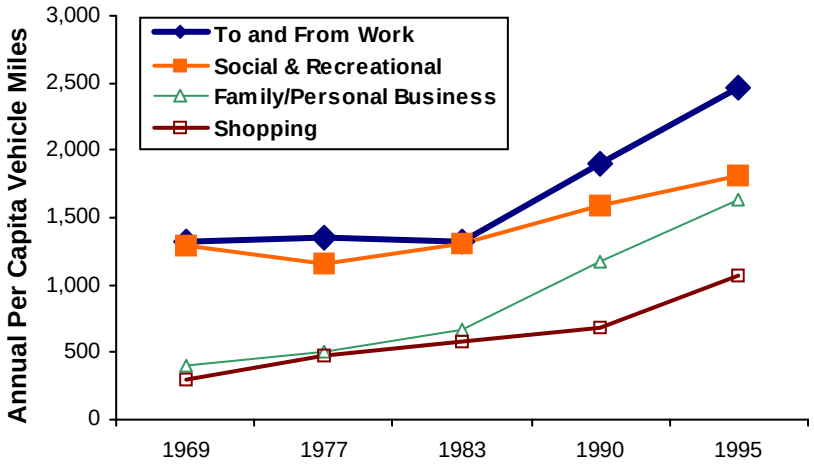
Similarly, cities such as Portland, Oregon; Vancouver, B.C.; and Salt Lake City, Utah experienced significant ridership growth after new transit lines were opened and transit-oriented land use development occurred. For example, in Portland between 1990 and 2000, during which major transit service improvements were implemented, population grew by 24%, motor vehicle mileage by 35%, and transit ridership by 49%. Much of this ridership consists of discretionary riders who choose transit because it offers better service. The success of these systems, and the political support demonstrated for new urban transit system (many required public referenda for funding) indicates that many people want quality transit, and will use such services when available.

Trip Purpose

During the Twentieth Century there were significant changes in the character of personal travel. Early in the century, most people worked, shopped and socialized close to their home. They might enjoy an occasional recreational bike ride or out-of-town train trip, but most travel was functional and local.

As motor vehicle ownership grew, travel costs declined and households dispersed, people organized their lives around increased mobility. The greatest growth in motorized travel has involved non-commute personal trips, including shopping, social and recreational travel, and family/personal business, as indicated in Figure 12, which shows changes in vehicle mileage by trip purpose between 1969 and 1995. Although per capita commuting mileage increased, it declined as a portion of total vehicle mileage from 40% to 35% between 1969 and 1995.

Figure 12 **Vehicle Travel By Trip Purpose** (Hu and Young, 1999, Table 5)



This figure shows per capita vehicle mileage by trip purpose. Although all types of trips increased between 1969 and 1995, commuting declined as a portion of total personal travel.

This growth in non-commute trips can be considered a rational response to declines in the generalized cost (combined monetary, time, discomfort and risk costs) of travel. If driving is cheap and fast people will drive further for errands and recreational activities. If travel is cheap enough, some people will travel around the world for a weekend holiday. However, this additional travel is price sensitive, since it consists of lower-value travel that consumers only make when their costs are minimal. If vehicle costs or congestion delays increase, such non-essential trips tend to decline.[7]

[7] Economists would say that the travel demand curve has a long tail, meaning that as prices decline consumers will continue to increase their mobility, but the additional travel provides little net user benefit and will be avoided if prices increase.

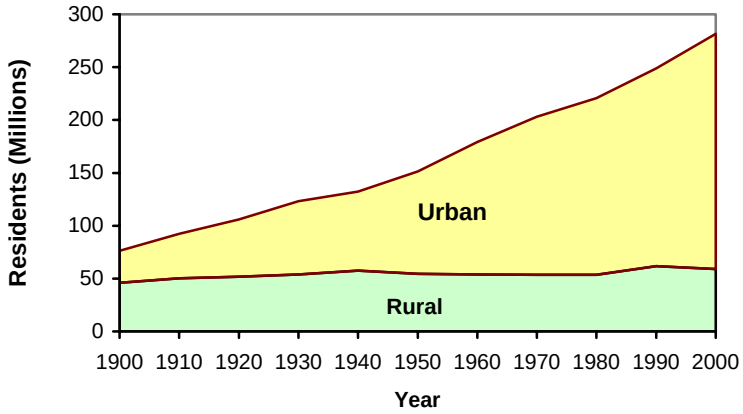
Factors Affecting Travel Demand

This section discusses several factors that tend to affect vehicle ownership and use, including income, vehicle costs, land use patterns, transportation options and consumer preferences.

Demographics

During the last century the U.S. population grew from 76 million to 275 million residents. Virtually all of this growth occurred in urban areas, defined as communities with more than 2,500 residents, as illustrated in Figure 13.

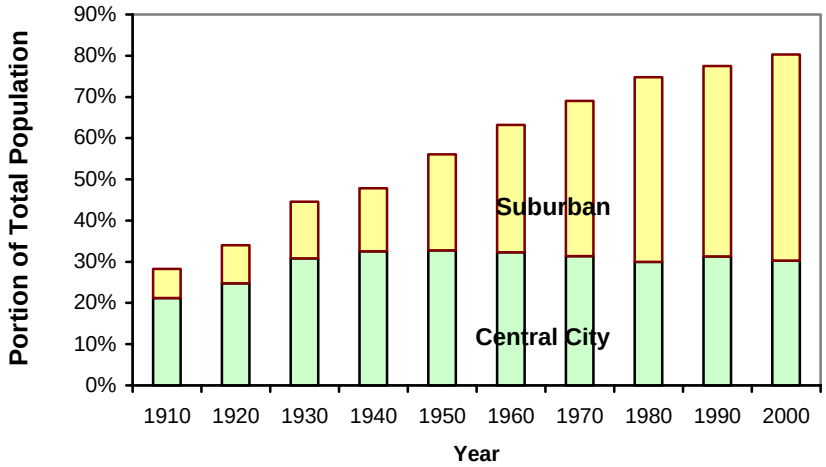
Figure 13 **U.S. Population** (US Census, 1998)



Nearly all population growth during the Twentieth Century occurred in urban areas.

During the second half of the Century most population growth occurred in suburban communities, outside central cities but within commute distance. By the year 2000, nearly 80% of the U.S. population lived in a metropolitan region, and 62% of metropolitan residents lived in suburbs, representing half of the total population.

Figure 14 **Central City and Suburban Populations** (US Census, 2002a, Table 1-15)

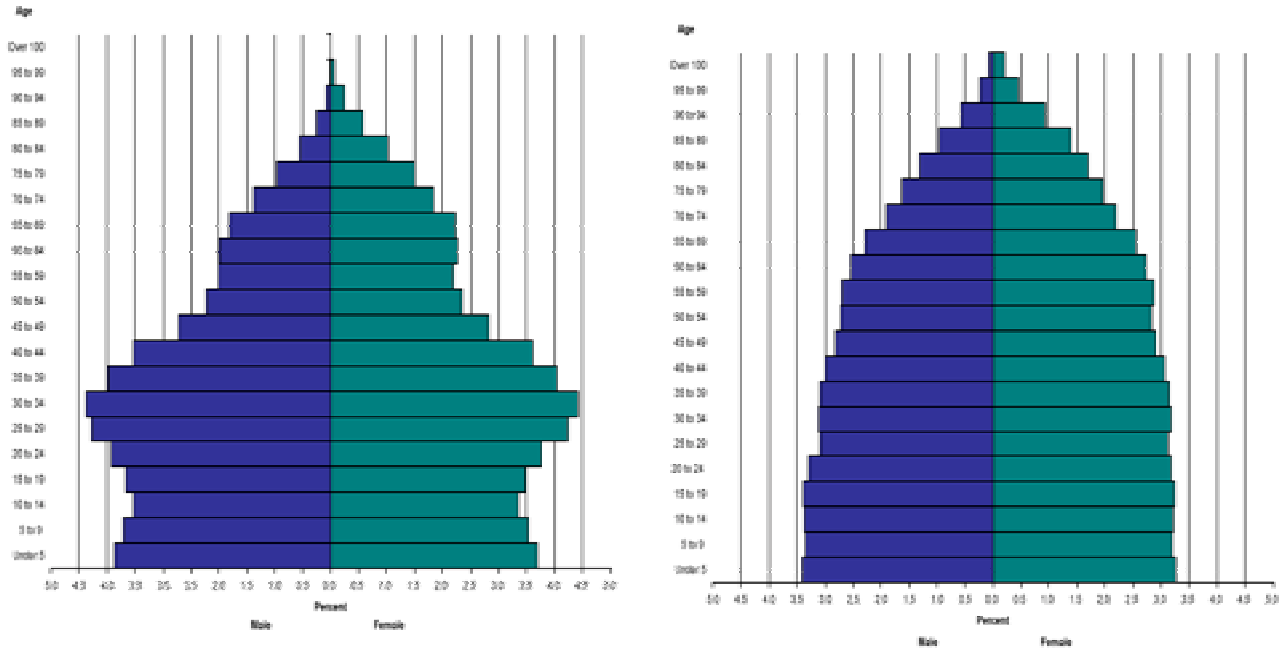


During the Twentieth Century, an increasing portion of the U.S. population lived in metropolitan regions, particularly in suburban jurisdictions.

The U.S. population is projected to grow to nearly 400 million by 2050, a large absolute increase but a decline in the annual growth rate from 1.1% during the 1990s to 0.5% expected in the 2040s (Cheeseman Day, 2001). This decreasing growth rate is due to declining birth rates, a common phenomena in developed countries. From 2030 to 2050, the United States would grow more slowly than ever before in its history.

The population mix is projected to change significantly, with a much greater portion of elderly residents, immigrants and minority residents. Figure 15 shows U.S. population pyramids for 1990 and 2025. A dramatic change is projected to occur during the next twenty years as the Baby Boom ages.

Figure 15 **U.S. Population by Age and Gender** (U.S. Census, 2002b)

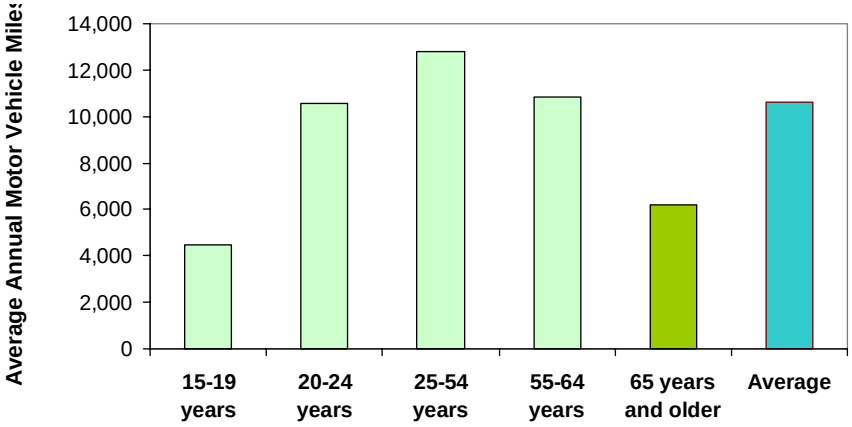


1990 **2050**

The U.S. population, and that of most other developed countries, is aging. During the next century the absolute number and portion of the total population that is retired and elderly is projected to increase significantly.

As the Baby Boom retires their per capita vehicle travel should decline, and their demand for alternative modes and more accessible housing location is likely to increase (AARP, 2005). Although Baby Boomers are likely to drive more than previous retirees, they are unlikely to drive as much as they did during their working years. As people age they tend to drive less, as illustrated in Figure 16. The most significant reduction occurs when they retire and so no longer commute, and annual mileage continues to decline as people age.

Figure 16 **Average Annual Mileage by Age** (BTS, 2003, Table A-17)



Annual motor vehicle travel declines significantly as people age.

Race and origin also tend to affect travel patterns. Minorities and immigrants tend to have relatively low per capita vehicle ownership rates, and relatively high alternative mode use rates (Battelle, 2000). For example, in 1997 the portion of households that do not own an automobile was 9.5% overall, 24.1% of African American households, and 15.3% of Hispanic households (Battelle, 2000, Table 4-5). Of immigrant households that have resided in the U.S. for less than three years, 20.7% do not own an automobile, five times higher than the 3.9% of U.S. born residents (Battelle, 2000, Table 4-6).

Income

Per capita automobile ownership and mileage tend to increase with income ("Travel Elasticities," VTPI, 2005), but this growth appears to level off and even decline at high income levels, due to saturation and improved travel and location options (air travel probably continues to increase at high incomes). Lower income countries tend to have the highest vehicle ownership and mileage growth rates, while higher income countries are experiencing low or negative growth.[8] An international study found that per capita automobile ownership peaks at about $21,000 (1996 U.S. dollars) annual income, and levels off or even declines with further wealth (Talukadar, 1997). Using U.S. data, Holtzclaw (2000) found that vehicle travel increases strongly with annual income up to about $30,000, but then levels off and declines slightly with incomes over $100,000.

Just as wealthier consumers tend to purchase more expensive vehicles for greater performance, comfort and prestige, wealthier cities tend to invest in higher quality public transit systems that offer superior service. In developed countries, cities with higher incomes tend to have better transit systems which result in higher per capita transit ridership rates (Hass-Klau and Crampton, 2002; Litman, 2004). This is one factor that explains why automobile travel does not always increase with income.

[8] International Energy Agency analysis indicates that in wealthier countries, per capita vehicle-kilometers tend to grow more slowly than GDP, particularly after average private motor vehicle ownership exceeds one per household (IEA, 2004).

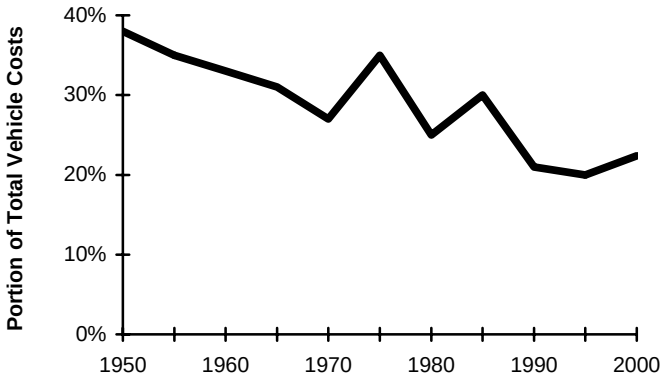
Vehicle Costs

During most of the Twentieth Century a middle-priced new vehicle generally cost 35% to 50% of average annual wages. For example, in 1914, a Ford Model T cost $220, about 40% of average annual wages. In 1953 a Plymouth Cambridge could be purchased for $1,618, about 48% of the average annual wage of $3,387. In 1967, an average new car sold for $3,212, 40% of $7,933 average household income; in 1977 the average car sold for $5,814, 36% of $16,009 average household income; and in 1987 the average new car sold for $13,657, 46% of $29,744 average household income.[9]

However, new car prices are a poor indicator of overall vehicle affordability because lower-income households tend to purchase less expensive used vehicles, because many vehicles include costly luxury features, and because vehicle ownership includes additional expenses such as registration and licensing fees, repairs, and insurance. For many lower-income motorists, insurance costs are a larger constraint on vehicle ownership than purchase costs. Ownership trends suggest that vehicles have become more affordable over time, as indicated by rising vehicle ownership rates among the lowest income quintile from 1970 through 2000.

Annual vehicle mileage is affected by the financial, time and discomfort costs of driving. Per-mile vehicle operating costs declined during most of the Twentieth Century, due to cheaper tires, increased vehicle reliability (and therefore less frequent repairs), increased vehicle fuel efficiency, and declining real fuel prices. Variable costs decreased relative to fixed vehicle costs, as indicated in Figure 17. This gives motorists an incentive to increase their mileage to earn a reasonable return on their fixed investment. Motorists think, "Since I spend so much on payments and insurance, I may as well drive."

Figure 17 **Vehicle Cost Trends** ("Cost of Driving," VTPI, 2005)

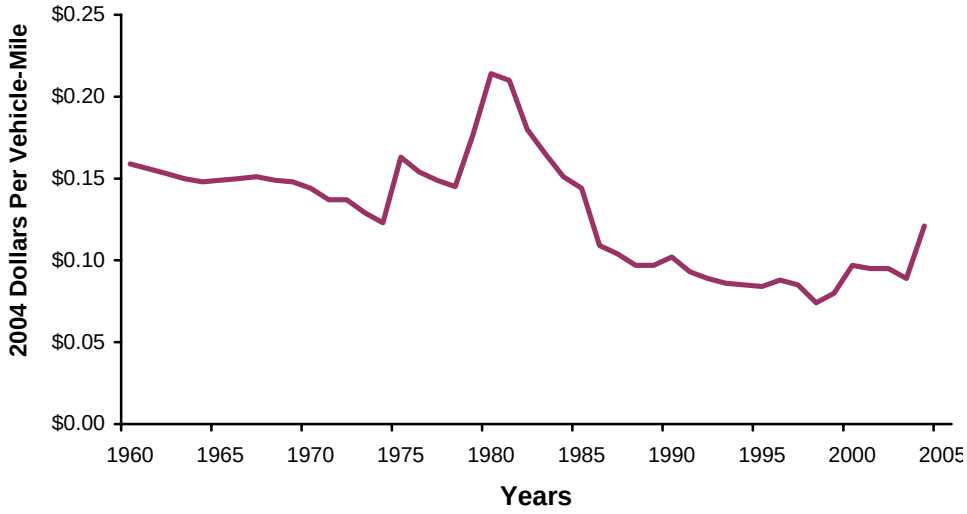


The variable portion of vehicle costs declined from about 40% in 1950 to 22% in 2000.

[9] Model T price information from *Forbes Greatest Business Stories* (www.wiley.com/products/subject/business/forbes/ford.html). Wage information is from the U.S. Census Department (www.census.gov/hhes/income/histinc/p53.html). Plymouth prices are from (www.allpar.com/old/plymouth/plymouth-1953-54.html). Information on average new automobile retail prices relative to wages, 1967 to 1994 is in MVMA 1995, p. 60.

Real fuel prices declined for most of the Twentieth Century, excepting a peak during the late 1970s and early 80s. In 1920 gasoline cost 30¢ a gallon, when wages averaged about 50¢ per hour. Fuel prices are predicted to increase during the Twenty-First Century as demand grows and production peaks (Magoon, 2000; Campbell and Laherrère, 1998; *Association For The Study Of Peak Oil & Gas* at www.peakoil.net). Although many substitute fuels are available, none is likely to be as cheap or convenient as petroleum was during the Twentieth Century.

Figure 18 **Per Mile Fuel Costs** (VTPI, 2004)



This graph shows fuel prices per vehicle-mile between 1960 and 2004. Real (inflation adjusted) fuel prices declined and fuel efficiency increased during this period, reducing per-mile costs.

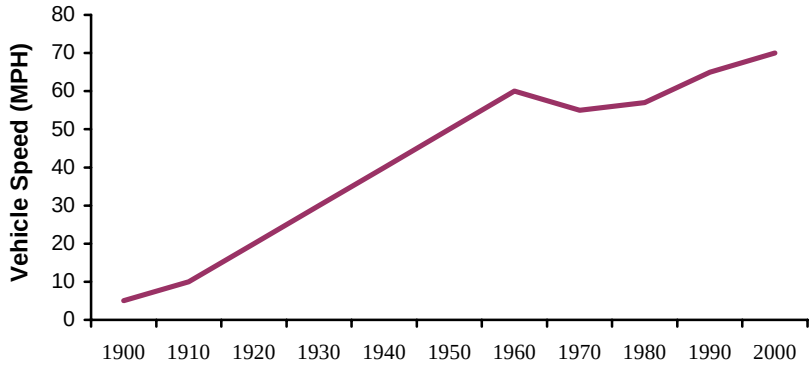
Rising energy prices will probably cause only modest mileage reductions during the foreseeable future. Taxes and distribution costs represent half or more of the retail price of fuel, so doubling wholesale petroleum costs only increases retail prices by 50%. The long-run price elasticity of vehicle fuel is –0.3 to –0.7, meaning that a 10% price increase causes consumption to decline by 3% to 7% over the long run, but about two thirds of this results from the purchase of more fuel efficient vehicles and only about a third results from reduced travel ("Transport Elasticities," VTPI, 2005). The U.S. vehicle fleet is particularly inefficient compared with its technical potential: vehicles currently average about 20 miles-per-gallon (mpg), while hybrid vehicles are now available with performance that could satisfy most trip requirements that average more than 60 mpg. As real fuel prices increase during the next few decades, motorists will probably trade in their gas guzzlers for fuel efficient vehicles and only reduce their per capita vehicle mileage by a modest amount.

During the Twentieth Century driving became significantly more convenient, comfortable and safer per mile of travel due to improved vehicle and road design. Incremental improvements will probably continue, with quieter operation, more comfort and safety features incorporated in lower-priced models, but future improvements will probably be modest compared with what occurred in the past.

Travel Speeds

Travel speed affects per capita mileage. People tend to devote an average of about 1.2 hours per day to travel. Higher speeds allow more mileage within this time budget. Average travel speeds increased between 1900 and 1970, due to vehicle and roadway improvements. Before 1950 few cars could exceeded 60 miles per hour (mph), and few roads were suitable for such speeds, but in the last half-century virtually all cars and most new highways have been designed to accommodate faster travel.

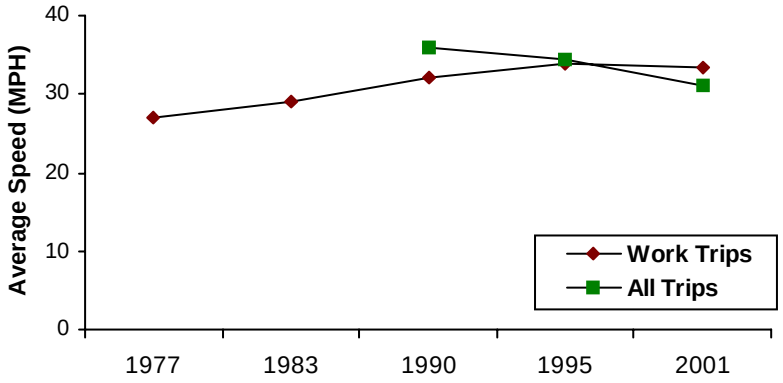
Figure 19 **Estimated Feasible Vehicle Speeds**



This figure shows how maximum feasible (safe and legal) vehicle speeds increased over the Twentieth Century, from walking and cycling speeds to 65 miles-per-hour on modern highways. Of course, not all travel occurs at these maximum speeds.

Interstate highway speed limits were reduced to 55 mph in the mid-1970s, raised to 65 mph in 1987, and since raised to 75 mph in a few areas, but it is unlikely that overall average travel speeds will increase significantly in the future. Although posted speed limits may increase on some highways, the effects will probably be offset by reduced speed limits elsewhere, improved speed enforcement, and increased congestion. Travel surveys indicate that average speeds increased during the 1970s and 80s, but declined during the 1990s (Figure 20). U.S. Census average commute times increased from 21.7 to 25.5 minutes between 1990 and 2000 (Polzin, Chu and Toole-Holt, 2003, Figure 29).

Figure 20 **Average Travel Speeds** (Polzin, Chu and Toole-Holt, 2003, Figure 27)

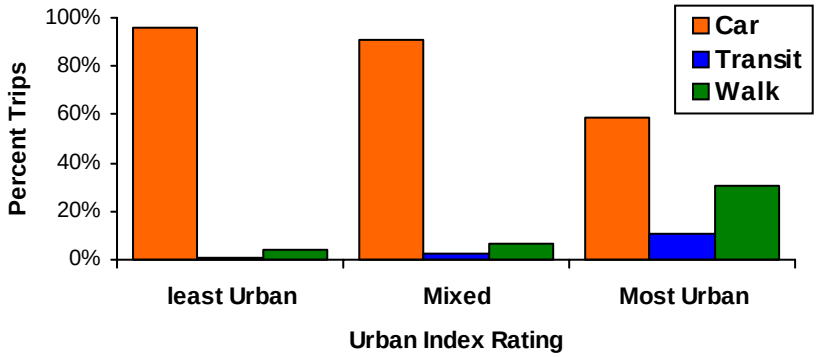


Average Travel Speeds increased during the 1970s and 80s, but started to decline in the 1990s.

Land Use

Land use patterns have a major effect on travel patterns ("Land Use Impacts on Transport," VTPI, 2005). Residents and employees located in more accessible, more multi-modal locations tend to own fewer motor vehicles, drive less, and use alternative modes more than those at automobile-dependent locations (Figure 21). Per capita mileage reductions of 20-40% are common when people move from an automobile-dependent suburb to a multi-modal, New Urbanist neighborhood, and similar reductions in automobile commute trips are common when employees shift from suburban to city center worksites ("Smart Growth," VTPI, 2005).

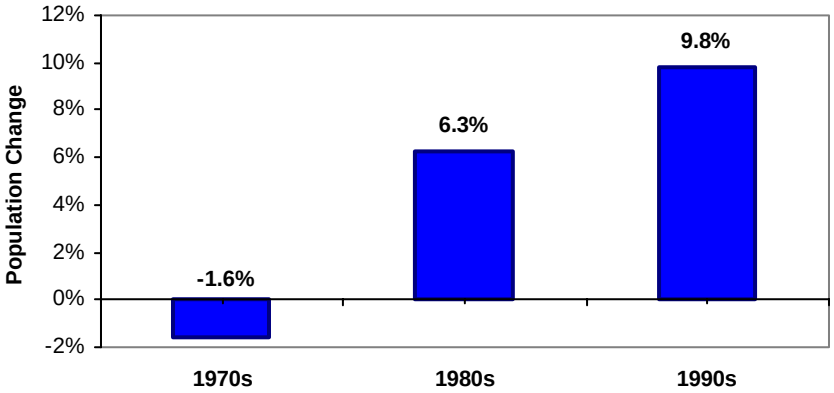
Figure 21 **Urbanization Impact On Mode Split** (Lawton, 2001)



Public transit and walking transport increase as an area becomes more urbanized.

As mentioned earlier, during the second half of the Twentieth Century most growth occurred in suburbs, reducing average population densities, while central city populations declined. However, in recent years population densities have increased as suburbs infill, and major North American cities have experienced population and employment growth, as illustrated in Figure 22.

Figure 22 **50 Largest U.S. Cities Growth Trends** (U.S. Census)



City populations declined during the 1950s through the 70s, but grew during the 1980s and 90s. This indicates that many consumers prefer urban living. Demographic (smaller households and an aging population) and market trends (New Urbanism) support city population growth.

There are many explanations for this, including declining urban crime rates and improved urban services, demographic shifts, a growing appreciation of urban living, and improved urban design. In recent years the New Urbanist movement has encouraged cities to re-embrace traditional urban attributes such as density, land use mix, walking and transit. New Urbanist developments include a variety of housing (small-lot single-family houses, town houses, condominiums, lofts, etc.), located in mixed-use neighborhoods, often near transit stations. Although the initial results were mixed, with some projects that fail either in terms of their design or market goals, developers have learned to build better products that attract occupants and earn profits.

During the second half of the Twentieth Century, many U.S. cities became more suburbanized, with declining population densities, more single-family housing, increased emphasis on automobile transportation, and increased parking supply. More recently, cities have begun to reemphasize true urbanism, with increased emphasis on density, land use mix and alternative travel options. Suburbs are also becoming more urbanized. Many suburbs, towns, master-planned communities and resorts are now also developing compact, walkable centers, encouraging alternative modes, and managing transportation and parking in new ways.

Market and demographic trends are increasing demand for multi-modal urban locations: condominium sales are growing and for the first time the price midpoint of condos is higher and the sales volume is growing faster than for detached single family homes; market surveys indicate that 71% of older households want to live within walking distance of transit; and more than a third of all households want small lots and clustered development; a quarter of all home buyers would like to live within a half-mile of a rail transit station (Reconnecting America, 2004). Urban living is now "cool," and increasingly popular with the middle-class, including younger and retired people.

Transportation Planning and Investment Practices

Transportation planning increasingly favors more diverse transport systems. In the last few decades, transportation professionals, public officials and the general population have become more familiar with, and accepting of, more multi-modal transportation strategies, as indicated by more multi-modal planning activities at federal, state, regional and local levels, and by the adoption of concepts such as intermodalism, context sensitive planning, transportation systems management, transportation demand management, and more integrated transportation and land use planning (i.e., "Smart Growth").

During most of the Twentieth Century transportation investments focused on roadway building, culminating in the development of the U.S. Interstate Highway System, and similar grade separated highway systems in other countries. This was probably quite rational. If inadequate roads are a constraint to economic activity, highway investments often provide significant economic productivity benefits by reducing transport costs (Hodge, Weisbrod and Hart, 2003).

The incremental economic benefit of additional roadway capacity is declining in developed countries (Helling, 1997; Goodwin and Persson, 2001; Shirley and Winston, 2004). A CBO (1998) study calculated that highways showed 54% annual return on investment during the 1960s, but this declined to 9% by 1991. Table 2 shows how highway investments enjoyed higher economic returns than private capital investments during the 1950s and 60s, but returns declined below private investments by the 1980s, and these trends are likely to continue, since the most cost-effective roadway investments have already been made.

Table 2 **Annual Rate of Return** (Nadri and Mamuneas, 1996)

	Highway Capital	**Private Capital**
1950-59	35%	13%
1960-69	35%	14%
1970-79	16%	12%
1980-89	10%	11%

Roadway investments provided much greater economic returns than private investments during the 1950s and 60s, but this declined as the highway system was completed. Since the 1990s additional highway capacity expansion provided lower returns than private investments.

During the last fifty years, fuel taxes per vehicle mile have declined due to the effects of inflation and increased vehicle fuel economy (Wach, 2003). Voters are reluctant to support tax increases to maintain past funding levels per vehicle-mile of travel. Increasingly, roadway improvements are funded through special referenda, often as packages that include a combination of highway and transit investments. Although highway officials complain about inadequate funding, this trend may be rational, reflecting the declining marginal benefits from roadway capacity expansion. Citizens are skeptical that highway building is a cost effective way to solve traffic problems and improve overall transport system performance. Although there is by no means unanimity, citizens increasingly seem to prefer alternative solutions, which explains a growing willingness to support commuter-oriented transit services and Smart Growth strategies.

Vehicle production and use may have provided economies of scale during much of the Twentieth Century (McShane, 1994, p. 105). At that time you benefited if your neighbors purchased more automobiles and drove them more miles because this reduced the unit costs of vehicles and paved roads. But once the automobile industry developed and a basic road network was built these external benefits decline and are offset by congestion.

The automobile industry is now mature and overcapitalized. World vehicle production capacity significantly exceeds demand. As a result, vehicle manufacturing profits are low and likely to decline in the future. Although the automobile industry was once a leader in providing good wages, benefits and local taxes, this is no longer true. Many other industries now pay comparable or better wages, and manufacturers demand various financial incentives from governments (tax rebates, infrastructure expenditures and training programs) in exchange for locating industrial facilities in a jurisdiction, capturing much of the economic benefits. As a result, there is declining justification for public polities that favor the automobile industry.

New Technologies

New technologies may affect future travel demand, but probably not the way many people expect. As described earlier in this paper, many people assume that transportation progress consists of newer, faster, more automated modes replacing older, slower, modes, but that is not always the case. For example, despite large subsidies and public support, supersonic air travel proved commercially unsuccessful and is unlikely to become common in the foreseeable future. Segways have yet to be widely used. Flying cars, if they ever become available, will probably have limited applications, do little to reduce urban traffic and parking congestion, and will probably increase other transportation problems such as air and noise pollution, and accident risk.

There is no shortage of potential transportation technological innovations.[10] Most consist of new drive system or a variation of public transit. Although some may have useful applications and help address specific problems, none seems to offer significantly better mobility than what currently exists for common local trips such as commuting or errands.

In general, technological improvements that reduce the financial, time or discomfort costs of driving increase vehicle travel, while those that improve alternative modes or management strategies (such as road or parking pricing) tend to reduce vehicle travel. During the Twentieth Century technological innovations significantly improved vehicle performance (power, speed and handling), comfort and safety. During the next century innovations are likely to improve traffic control and management. Many of these tend to reduce vehicle travel or have mixed impacts. For example, improved driver navigation may encourage people to take more vehicle trips, but reduce excess cruising by motorists searching for parking spaces.

Table 3 categorizes new transport technologies according to their likely vehicle travel impacts. More are likely to reduce motorized travel than are likely to increase it.

Table 3 **Travel Impacts Of New Transport Technologies**

Increases Motorized Travel	Mixed Mobility Impacts	Reduces Motorized Travel
Increased fuel efficiency and cheaper alternative fuels. Increased vehicle comfort. Automated driving.	Electronic vehicle navigation Improved traffic signal control.	Telework (electronic communication that substitutes for physical travel). Improved road and parking pricing. Improved transit user information. Transit service improvements. Improved rideshare matching. Improved delivery services. Improved carsharing services.

Some new technologies tend to increase vehicle travel, others tend to reduce it.

[10] For example, the *Innovative Transportation Technologies* website (http://faculty.washington.edu/~jbs/itrans) identifies several dozen.

The mobility effects of some new technologies are discussed below.

Telework

Telework refers to the use of electronic communication to substitutes for physical travel, including commuting, business activities and errands such as shopping and banking ("Telework," VTPI, 2005). Many jobs and errands involve information-related goods suitable for telework, but the actual portion of trips reduced by telework tends to be small. Many trips require access to special materials and equipment, or face-to-face meetings, even if their primary good is information that can be transmitted electronically. Not all employees want to telework or have suitable home conditions. Although it tends to reduce peak-period trips, telework does not necessarily reduce total vehicle mileage unless implemented with other travel reduction strategies, for the following reasons:

- Teleworkers often make additional errand trips that would otherwise be made during commutes, and vehicles not used for commuting may be driven by other household members.
- Employees may use teleworking to move further from their worksite, for example, choosing a home or job in a rural area or another city because they know that they only need to commute two or three days a week. This may increase urban sprawl.
- Improved telecommunications may increase long-distance connections, increasing travel. For example, people may make new friends through the Internet and travel more to visit them.

New Modes

Some new modes could develop during the next century, such as Personal Rapid Transit (PRT), Magnetic Levitation (Maglev) trains, flying cars, Segways, and their variants. There may also be new transport services, such as commercial space travel and more underwater tunnels replacing ferry travel. Their overall impacts are likely to be modest since they only serve a small portion of trips. For example, even if Maglev technology is perfected, it is only suitable for medium-distance (30-300 mile) trips on heavy traffic corridors. It may increase long-distance commuting in a few areas but have little effect on other travel. Only if Maglev systems stimulate transit oriented development (compact communities designed around transit stations) is overall travel likely to change, and this will result from land use changes, not the technology itself. Similarly, Segways are unlikely to affect overall travel unless implemented with urban design and traffic management changes to favor local, slower-speed modes over automobile traffic.

Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) apply computers and electronic communication to improve transport services. Although ITS research initially focused on automated driving, which probably would increase vehicle travel, implementation of this strategy has been slow. It seems unlikely that driverless cars will become widely available during the foreseeable future. So far, ITS successes consist primarily of driver information and navigation services, transit user information, transit priority systems, and better road and parking pricing, which tend to reduce rather than increase motor vehicle travel.

Alternative Fuels

Various alternatives may replace petroleum as the primary vehicle fuel, but virtually all currently being developed will be more expensive than what petroleum cost in the past, and most impose their own problems. From a motorists' perspective the primary change will be a gradual increase in costs over the century, regardless of which fuel is used.

Consumer Preferences

It is difficult to measure consumer preferences, and more difficult to predict how they will change in the future, but there are many indicators that consumers' often-mentioned "love affair" with automobiles is losing its passion. This occurs, in part, simply because it would be difficult for automobiles to capture more affection, or a greater share of consumers' financial and time budgets, than occurred during the Twentieth Century.

For many people, automobile travel is more than just a form of mobility, it is also a symbol of success and freedom. Because of this status and symbolic value many consumers purchase more vehicles, more expensive vehicles, drive more, and avoid alternatives more than is rational. But consumer enthusiasm tends to wane over time as the novelty wears off and newer products compete for attention.

During the Twentieth Century, walking, cycling and riding public transit travel were stigmatized, but in recent years alternative modes have become more socially acceptable. For example, bicycle commuting is increasingly accepted and even prestigious. Transit travel is also increasingly accepted as urban living becomes more popular and where service is upgraded.

The near universal enthusiasm, even obsession, young men had for automobiles seems to be declining. As automobiles become more sophisticated and complex they offer fewer opportunities for the bonding that results from tinkering. Newer automobiles seldom need tune-ups or repairs, and they require sophisticated tools operated by trained technicians. Many younger people are more excited about electronic equipment such as cellular telephones and computers than automobiles. The portion of 16 and 17 year olds licensed to drive has declined from 52% in 1992 to 43% in 2002, in part due to increased requirements and costs, but probably also due to waning interest (Hubler, 2004).

There are other factors that may help shift consumer preferences toward more multi-modal transportation systems. For example, experts and individuals are increasingly concerned about the health impacts of a sedentary lifestyle. Market surveys indicate that consumers increasingly value opportunities to walk and bicycle in their communities.

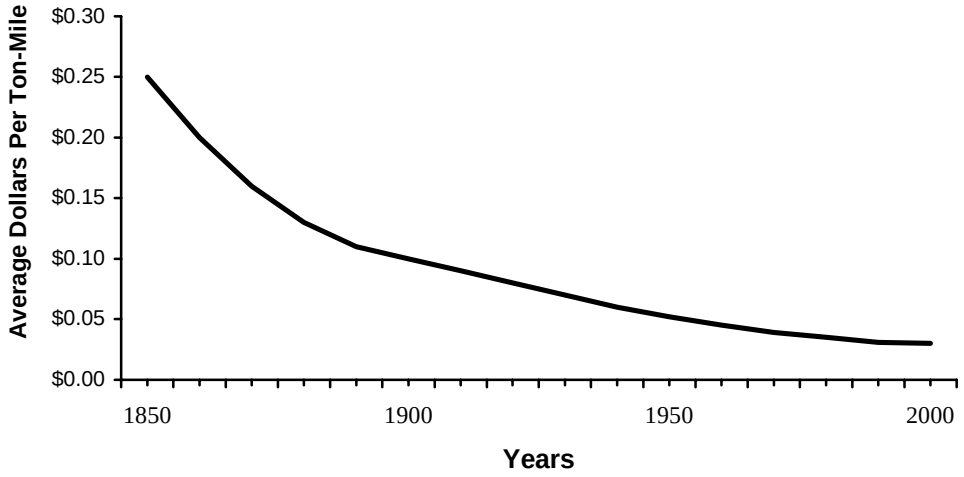
As mentioned earlier, urban living has become more convenient, secure and socially acceptable. Housing location preferences depend on how questions are worded. If consumers are asked to choose between a large-lot, single-family suburban home, or an apartment in a typical urban neighborhood, most (usually about 90%) will choose the suburban home. But if asked to choose between a large-lot suburban home and a small-lot home in a high-quality urban neighborhood, many (usually a quarter or more) will choose the urban location, and this is likely to increase in the future due to demographic and market trends (Belden Russonello & Stewart, 2004; Litman, 2005a).

This is not to deny that most households want to own an automobile and many want a large-lot suburban home. But demand for these seems to be declining somewhat, while demand for more multi-modal, urban lifestyles is likely to grow.

Freight Transport

The Twentieth Century experienced a huge increase in freight transport, due to declining shipping costs, increased shipping speeds, increased trade and industrial growth. At the start of the century freight was transported by horse-drawn wagon, railroad and sail or steam ships. This was expensive, slow and unreliable. Over time, trucks replaced horses, and the scale and efficiency of rail and marine transport increased. During the second half of the Century, containerization, intermodalism, deregulation, and various technical and logistical improvements continued to reduce shipping costs and increased speeds, particularly for long-distance travel. Unit costs often declined by an order of magnitude over the Century. Although technical improvements are likely to continue, particularly increased use of information technologies to automate and optimize flows, future cost reductions are likely to be more modest, and may be offset by increased fuel prices, particularly for truck transport. When transport costs are a major portion of total retail prices, transport cost reductions significantly increase sales and shipping volumes, but further cost reductions have less impact.

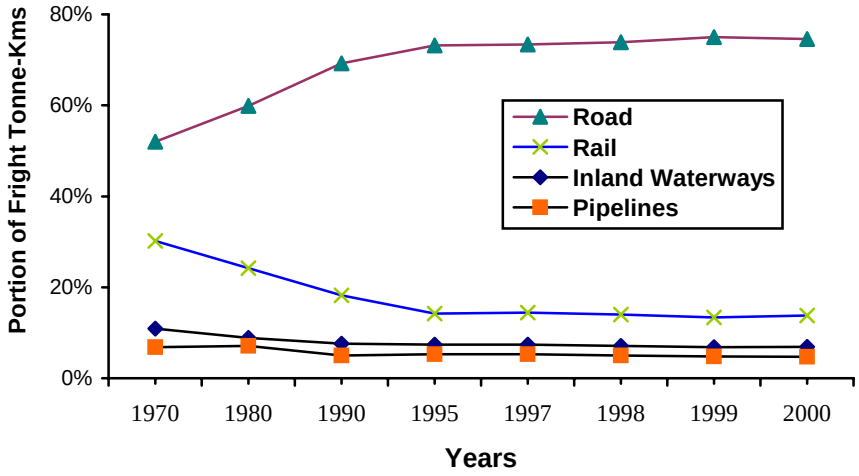
Figure 23 **Railroad Freight Costs** (Garrison & Levinson, 2006, p. 290)



Shipping costs per ton-mile declined significantly during the last 150 years.

As with personal travel, road transport grew as a portion of total freight transport through most of the Twentieth Century, but this growth leveled off and has even declined a little at the end of the Century, as illustrated in Figure 24. This reflects, in part, growing containerization, which is shifting more freight to rail and marine transport for medium and long-distance trips. Many European countries have policies encouraging such shifts.

Figure 24 **European Freight Mode Split** (EC, 2002, Table 3.4.3)



Road transport grew as a portion of total freight tonne-kilometers during most of the Twentieth Century, but the growth rate has leveled off and declined a little in 2000.

Freight transport volumes are likely to continue growing, particularly on corridors carrying international products, and in major distribution and industrial centers. In other areas, freight traffic is likely to grow more slowly, reflecting declining population and heavy industry growth rates. An increasing portion of freight transport will be by rail and marine modes.

Travel Trend Summary

The Twentieth Century was a period of tremendous growth in motor vehicle ownership and use, due to various demographic and economic trends. During this period the generalized cost of driving per vehicle-mile declined by an order of magnitude, due to declining fuel costs, and improvements in vehicle and road designs. This explains the order of magnitude increase in per capita vehicle mileage. In 1900 most people lived and worked on farms, and a typical urban commute was a one-mile walk or a three-mile trolley ride. In the 1920s and 30s only wealthy people could afford daily automobile commuting. Now, most people drive ten to twenty miles to work each day, and even more for errand and recreation travel.

Many of the factors that contributed to vehicle travel growth have peaked. It is unlikely that per capita vehicle ownership, automobile mode split, the amount of time people devote to driving, or average vehicle traffic speeds will increase significantly in the future. On the contrary, per capita vehicle travel will probably decline somewhat during the medium and long-term due to demographic, economic and geographic trends summarized in Table 4. Other researchers have reached similar conclusions (Lave, 1991; Polzin, Chu and Toole-Holt, 2003).

Table 4 **Factors Affecting Future Vehicle Travel**

	Impacts on Vehicle Travel
Demographics	Significant declines likely due to aging
Income	Mixed. Increased mileage likely among groups that shift from low- to medium-income, but little growth likely among middle- and higher-income groups.
Operating Costs	Moderate to large declines likely over the long term.
Travel Speeds	No change expected.
Land Use Patterns	No change or decline likely due to more smart growth development patterns.
Planning and Investment Practices	Some declines likely, particularly in urban areas, due to increased highway congestion, traffic management and emphasis on alternative modes.
New Technologies	Some declines likely due to improved alternative modes and traffic management strategies.
Consumer Preferences	Some declines likely due to increased preference for alternative modes and walkable communities.
Freight transport	Further growth in traffic likely, but the rate of growth will probably decline, and be concentrated in certain areas.

This table summarized various factors that are expected to affect future vehicle travel.

The Twentieth Century was a period of declining vehicle costs. The Twenty First century will be a period of declining communication and computing costs, which improves mobility substitutes and management strategies. This may reduce vehicle travel.

In higher-income countries, reductions in per capita vehicle travel should approximately offset population growth over the next half-century. Automobile ownership and use will probably grow in some areas and among some demographic groups, particularly those transitioning from poverty to middle-income wealth. Communities with low population growth rates, or that have high population growth rates but apply Smart Growth

development patterns and mobility management strategies, may experience no growth in local Vehicle Miles Traveled (VMT), although through traffic may increase on major corridors, particularly long-distance freight transport. A U.S. Department of Transportation study predicted VMT will grow between 1.91% to 2.26% annually during the next two decades, leading to a 62% total increase between 2001 and 2025, assuming a middle growth rate (Polzin, Chu and Toole-Holt, 2003, p. 21), but that analysis did not account for some of the factors identified in this paper, and so may be high.

Are there counter trends that may cause automobile ownership and use to increase among middle- and higher-income people? I can think of three. The first is the increased comfort of modern cars. It is possible, for example, that some people may commute longer distances and increase their recreational driving because newer cars have more comfortable seats, better stereos and cellular telephones. The second is simply the momentum of current, automobile-oriented development patterns, which may lead even more people to high-mileage lifestyles. The third is increased security concerns that may discourage public transit use. However, none seems likely to offset the trends identified in this paper. By late Twentieth Century, vehicles were already quite comfortable and most households already lived high-mileage lifestyles. Security concerns may motivate some people to reduce discretionary travel and locate in more accessible communities where they are less vulnerable to transport system disruptions.

The greatest issue of uncertainty is the degree to which consumer preferences will continue to favor automobile travel. During the Twentieth Century, automobile transport and suburban housing were considered exciting and glamorous. There are signs that consumer attitudes are changing. Although few motorists are likely to give up driving completely, there is evidence that many would prefer to drive less and use alternatives more, provided that they are convenient, safe and affordable. Similarly, although most households prefer to live in single-family homes, a significant portion seem willing to consider New Urbanist neighborhoods with higher densities and increased land use mix, provided they have other desirable attributes, such as security and prestige.

Although transport demand is likely to increase by 40-60% during the next half-century, due to population growth, this does not mean that vehicle mileage must increase by that amount. For various reasons mentioned in this paper, travel demand will be increasingly amenable to mode shifts, because the greatest growth in demand will take place on major urban corridors where walking, cycling and transit are effective; because consumers increasingly accept alternatives; and because transport professionals are applying mobility management strategies.

Implications For Planning

People sometimes assume that transport progress is linear, with newer, faster modes replacing older, slower modes. They consider older modes unimportant, so for example, there is no harm if automobile traffic slows bus service or degrades walking conditions. From that perspective it would be backward to give priority to transit or nonmotorized modes. But progress can actually follow a parallel model, with many modes being important simultaneously. Sometimes the best way to improve transport is to improve walking and cycling conditions, improve transit service, regulate vehicle traffic, or improve land use accessibility.[11] Such strategies do not necessarily increase travel speed; they may instead increase user convenience, comfort, safety and efficiency.

Good planning involves more than simply extrapolating past trends. It is particularly important to anticipate future needs correctly because transport planning decisions can be self-fulfilling. For example, if we expect automobile transport to be dominant, we will devote most transportation resources to expanding roads and parking facilities, and locate destinations for automobile access, creating the predicted travel patterns. Because roadway capacity expansion is costly and tends to fill with generated traffic, such projects could consume virtually any allocation of resources. However, if we expect demand to become more diverse we will implement different policies, helping to create a more balanced transport system.

Transportation engineers practicing during the peak growth years of 1940 through 1990 often found that the facilities they developed quickly became outdated. Numerous two-lane roadways were widened to four lanes, but soon become congested, leading to calls for six and eight traffic lanes. Parking facilities sized to accommodate one vehicle per household were insufficient as more households purchased multiple vehicles. Highways designed in the 1940s and 50s were inadequate for the higher vehicle speeds that soon developed. As a result, engineers learned to overbuild in anticipation of growing traffic volumes and speeds. Practices that may have made sense in the past, such as overbuilding roads and parking facilities, may be harmful if applied in the future.

For example, reduced per capita vehicle ownership has important implications for setting parking requirements. Until the 1980s transport professionals could justify requiring relatively generous amounts of parking for new development, more than was actually needed at the time, on the grounds that it anticipated future needs. This is no longer appropriate. Parking requirements based on demand studies performed during the 1980s are likely to be excessive in the future due to declining per capita vehicle ownership rates.

These trends also have implications for transportation finance. Real (inflation adjusted) per capita fuel tax revenues are declining, so either tax rates must increase, alternative revenue sources must be provided, or transport investments must be reduced.

[11] In fact, science fiction visions of future transport often include considerable walking, quality public transit services, well-designed urban environments, and other features of an efficient and diverse transport system.

Historical Timeline

A useful approach for thinking about future transportation planning issues is to consider how new issues were introduced, as indicated in Table 5. Virtually none of these issues have disappeared, they continue to expand the scope of factors that planners are expected to take into account in decision-making. New issues are likely develop in the future.

Table 5 **Transport Planning Issues Timeline**

Decade	New Issues
1900	Railroad system development (railroad mature, automobiles are novelties)
1910s	Roadway funding ("good roads" movement) Automobiles as utilitarian vehicles
1920s	Roadway planning, design, contracting practices and materials selection Vehicle design improvements
1930s	Urban traffic congestion Traffic and parking management, regulation and enforcement Traffic safety Commercial air travel
1940s	Support for military and industry activities Expanding vehicle production (post war) Suburbanization/arterial expansion
1950s	Freeway system planning and funding Transportation computer modeling
1960s	Interstate highway system design construction Urban transit funding and planning Intermodalism/freight containerization
1970s	Environmental concerns Energy security and conservation Transportation systems management
1980s	Transportation demand management Traffic calming Basic mobility services (demand response transit services) Access management Deregulation
1990s	Sustainable transportation Nonmotorized (walking and cycling) transport planning Integrated transportation/land use planning Context Sensitive Design/community livability
2000	Roadway operations Public health (physical activity and fitness) Security (terrorism threats) Emergency response and disaster evacuation Transportation pricing and financing innovations Smart Growth/New Urbanism
Foreseeable Future	Rising fuel costs/alternative fuels Intelligent Transportation Systems Aging population ???
Far Future	???

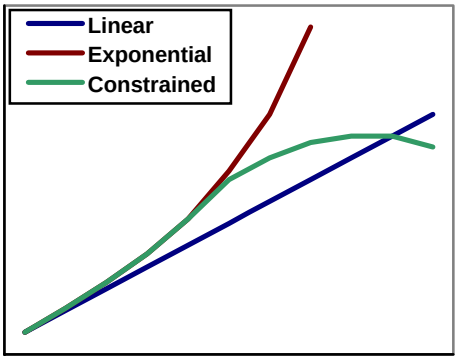
This table illustrates when new transportation planning issues have been introduced over the last century. None of these issues has disappeared. Planners are expected to understand virtually all of these issues and take them into account in policy and planning decisions.

Growth Versus Development

Economists sometimes make a distinction between *growth* (increased quantity) and *development* (increased quality). A transport system need not *grow* in vehicles, vehicle-miles, passenger-miles, ton-miles or traffic speeds, to *develop* and become better. Improvements can increase efficiency, improve comfort and safety, and reduce the amount of physical travel require to satisfy people's needs.

Growth, whether biological or economic, tends to follow certain patterns, as illustrated in Figure 25. Some growth is linear, a steady increase: 1, 2, 3, 4, 5… Some growth is exponential, the rate increasing over time: 1, 2, 4, 8, 16… Physical products and activities cannot grow exponentially forever. Rapid growth eventually encounters constraints. As a result, change often experience cycles of slow growth, rapid growth, declining growth, and negative growth, followed by a new cycle.

Figure 25 **Growth Patterns**



Growth tends to follow certain patterns. Most activities experience periods of rapid growth, followed by slower growth due to constraints and increased competition.

Biological growth is generally controlled by resource constraints, such as food, clean water and space, or because population growth stimulates predators and disease. Growth of economic activities may be affected by resource constraints, by market saturation, and by competition. When a new product or technology is first introduced it may provide large benefits, but marginal benefits tend to decline, and new products are often introduced that compete with existing products. For example, the first few motor vehicles in a community generally provide large benefits because they serve high-value trips: emergencies, deliveries and public transport. But as the vehicle ownership increases marginal benefits diminish because the additional vehicle travel consists of less valuable trips. In addition, traffic congestion increases, while road and parking capacity expansion tends to be less beneficial, since the most cost-effective projects are already completed. Over time an increasing portion of automobile ownership and use reflect prestige value (i.e., to display wealth and status), providing no overall benefit to society. All these factors reduce the justification for public policies that support automobile traffic growth.

Increasing Transport System Diversity

The demand shifts identified in this paper indicate that society will benefit from developing a more diverse transport system and more multi-modal land use patterns (Litman, 2005b). This would, for example, more effectively serve a growing elderly population, anticipate the needs of commuters if fuel prices rise significantly, and serve people who prefer walking, cycling and transit travel over driving for some trips.

Total travel demand will continue to grow, particularly in areas with significant population increases, or along major international freight corridors. However, this does not necessarily mean that road and parking capacity must expand proportionately. Travel demand growth will primarily occur in urban regions, where traffic is concentrated and facility expansion costs are high. Alternative modes improvements and mobility management programs are often the most cost effective ways to improve transport in such areas (VTPI, 2005).

Increased transport system diversity does not eliminate automobile travel. On the contrary, automobiles will likely continue to be the primary travel mode for the foreseeable future, measured in person-miles. It means that more attention should be given to improving other modes, so they can accommodate a major portion of future travel demand growth.

Transportation policies and planning practices can be changed to create a more efficient and diverse transport system (VTPI, 2005). Many of these changes are already occurring to a degree, but much greater implementation can be justified (OECD, 2002; Row, 2003; ITE, 2003; Cairns, et al., 2004; VTPI, 2005; Litman, 2005b). For example:

- Planning and evaluation practices can be more comprehensive, taking into account a wider range of impacts and options. This tends to increase the recognized value of alternative modes, and reduce the value of accommodating additional automobile travel.
- Least cost planning principles can be applied, so that mobility management strategies, and support for alternative modes, are implemented when they are cost effective.
- Special efforts can be made to improve walking and cycling conditions, and to accommodate people with disabilities and other special needs (such as people using strollers and handcarts).
- Pricing reforms, including parking pricing, parking cash out (letting travelers choose between a parking subsidy or the cash equivalent), congestion pricing, pay-as-you-drive insurance and registration fees, distance-based road user charges, and cost-recovery pricing can be used to manage vehicle travel for efficiency.
- Land use development policy reforms can help create more multi-modal communities and increase land use accessibility.
- Public transit, ridesharing, taxi and carsharing services can be improved through increased investment, HOV prioritization, and technological innovations.
- Telework and delivery services can be improved to substitute for physical travel.
- Innovative marketing can be used to promote use of alternative modes, making walking, cycling, ridesharing and transit more convenient to use and socially acceptable.

Counter Arguments

Not everybody agrees that automobile transport has peaked or that consumers benefit from more diverse transport systems and Smart Growth. Some experts argue that society should accommodate increased automobile travel because it is beneficial, and that investments in alternative modes and Smart Growth land use policies are unjustified, wasteful and futile preferences (Green, 1995; Dunn, 1998; Pisarski, 1999). Automobile advocates tend to make the following errors ("Criticism of TDM," VTPI, 2005):

- They use selective data. For example, they generally cite trends during the 1960s through the 1990s, when per capita vehicle ownership and use grew fastest, and ignore trends since 1995 when growth rates declined and use of alternative modes started to increase.
- They frame the debate as a choice between high quality automobile transportation and low quality alternatives, ignoring problems of automobile use (such as inadequate mobility for non-drivers) and ways that that alternative modes can be improved. Similarly, when considering land use options, automobile advocates frame the debate between comfortable and safe suburban housing, and crowded, inferior, urban housing, ignoring the possibility of creating high-quality urban housing.
- They ignore many of the problems and risks associated with increased automobile dependency, and many of the benefits associated with a more diverse transport system. Some ridicule concerns about future energy supplies, climate change, the problems facing non-drivers in an automobile-oriented transport system, or health risks associated with sprawl. They often claim that technological progress will solve these problems, citing examples of technological successes and ignoring examples of technological failures.
- They ignore the increasing support for mobility management and Smart Growth by leading professional organizations (OECD, 2002; ITE, 2003; NAR, 2003; NGA, 2003).
- They ignore market distortions that favor automobile travel (underpriced road and parking facilities, and fixed vehicle insurance and registration fees, dedicated roadway funding, etc.), and the possibility that automobile travel would decline with more efficient pricing and more neutral planning practices ("Market Principles," VTPI, 2005).
- They claim that mobility management and Smart Growth strategies are "draconian" and harmful to consumers, ignoring the fact that most proposed mobility and land use management strategies rely on positive consumer incentives, and evidence that many people would prefer to drive somewhat less and rely more on alternatives.
- They assume that automobile travel demand is inflexible and cannot be reduced, ignoring successful, cost effective mobility management programs that reduce vehicle traffic growth ("Success Stories," VTPI, 2005).

Conclusions

Motorized mobility grew tremendously during the Twentieth Century. Over this period automobile transport evolved through a pioneer stage during which it was a novelty, to a growth stage during which motorized travel increased in volume and importance, and into its current mature stage during which automobiles are the dominant transport mode.

Between 1900 and 2000 per capita vehicle travel increased by an order of magnitude due to favorable technical, demographic and economic trends. But the factors that caused this growth are unlikely to continue. Toward the end of the Century per capita automobile travel stopped growing in the U.S., and started to decline after 2000, despite rising incomes. This decline is likely to continue due to demographic and market trends. An increasing portion of the population will need or prefer alternative modes such as walking, cycling, ridesharing, public transit, telework and delivery services. Automobile transport will continue to be important but the role of other modes will increase. Future motor vehicle travel growth will result from population growth rather than increased per capita vehicle ownership and use, as occurred in the past.

Transportation professionals should take these trends into account in strategic planning. If we continue to evaluate transportation system performance primarily in terms of motor vehicle travel speeds and congestion we could devote virtually all available transport improvement resources to expanding roadway capacity and yet provide no gain to society overall, due to diminishing marginal benefits and because direct user benefits are offset by increased external costs. Planning for a mature transport system means less emphasis on roadway expansion and more emphasis on infrastructure maintenance and management, with strategies to improve transport system efficiency and diversity.

Travel demand will be increasingly amenable to alternative modes and mobility management strategies. The degree to which travel patterns actually change will depend on our policy and planning decisions. Continuing current practices will tend to stimulate more automobile travel, but alternative approaches can help shift travel to other modes. It will no longer be appropriate for policy and planning decisions to favor automobile transport. On the contrary, there are good reasons to encourage alternative modes to help create more efficient and diverse transport systems that better serve future needs.

For example, if we start developing a new suburban highway now, it will be completed about the time that most Baby Boomers retire, fuel prices rise significantly, and consumers increasingly value walkable neighborhoods. It may be better to anticipate these trends by investing resources in alternative modes and creating less automobile-dependent communities.

Although this paper investigates transport patterns in wealthier, developed countries, the analysis has important implications for lower-income, developing countries. It indicates that even wealthy people benefit from transport system efficiency and diversity. Such benefits are even greater in countries with more limited resources. Developing country decision-makers have an opportunity to create efficient and diverse transport systems directly, and avoid the mistake of overemphasizing automobile transport.

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